MONANA

JOURNAL of the AUSTRALIAN METEOROLOGICAL ASSOCIATION

Vol. 2 No. 3, September, 1976

THE AUSTRALIAN METEOROLOGICAL ASSOCIATION

EXECUTIVE COMMITTEE

President	:	Mr. A.T. Brunt
Vice-President	:	Mr. J. Hogan
Secretary/Treasurer	:	Mrs. J. Bannister

COMMITTEE MEMBERS

Mr. L. Mitchell

Superintendent R. Calvesbert

Dr. B.J. Noye

Mr. T.G. Keen

Mr. B. Mason

Mr. W. Slaytor

EDITOR

Mr. T.G. Keen

All correspondence relating to " *MONANA* " should be addressed to the Editor:

Mr. T.G. Keen,
10 Hill Street,
BURNSIDE. S.A. 5066

OTHER correspondence relating to the Association should be addressed to:

The Secretary,
Australian Meteorological Association,
Mrs. J. Bannister,
196 Walkerville Terrace,
WALKERVILLE. S.A. 5081

CONTENTS

		Page
"THE MILLION DOLLAR ICEBERG	- J.G. Job	1
CLIMATIC NORMALS ARE INEFFICIENT	- Arnold Court	5
CONTINENTAL DRIFT AND ITS EFFECT ON PALAEOCLIMATES	- Prof. Von der Borch	20
SURVIVAL IN ANTARCTICA		24
NEW REGIONAL OFFICE - BUREAU OF METEOROLOGY, KENT TOWN, S.A.	- L. Mitchell	27

EDITOR'S NOTE: Contributions in the form of letters or articles by readers are most welcome.

"THE MILLION DOLLAR ICEBERG".

Resume of Talk Delivered to Meeting of the Australian Meteorological Association on 2nd December, 1975.

J.G. JOB.

Why Study Icebergs?

Firstly, they are interesting, and even beautiful. A scientist may be concerned with their formation, history, hydrodynamics, or melting processes.

An entrepreneur may be interested in the fact that icebergs are floating reservoirs of fresh water.

Icebergs form by calving from the continental icesheet or glaciers of Antarctica and represent about half the total annual accumulation of snow on the continent, a production equivalent to the total flow of the rivers of the continental United States.

They range in size from small chunks up to huge floating ice islands, hundreds of square kilometres in area. A typical iceberg one km^2 in area would supply Adelaide's water for a year, and would be worth perhaps $20 million if it were in the form of water in a reservoir rather than ice in the sea.

Icebergs can be located by satellite imagery, mostly locked in fast ice close to the coast. Many escape out to sea, drift around the continent, and eventually melt. Few survive to drift further north than 50^oS.

Can we make use of them?

The fact that the water is in the form of ice is a blessing in disguise. The water is self-contained in convenient super-tanker blocks, and it is far cheaper to tow an iceberg than it would be to pump liquid water over the same distance.

Nevertheless, the process is very complex hydrodynamically, largely because of coriolis forces arising from the effect of the rotation of the earth, which tend to make the iceberg move at right angles to the left of the desired direction, and give rise to a strange slow circling motion, especially if the winds are variable.

We think that a towing force equivalent to an acceleration of 3×10^{-5} m s^{-2} will be sufficient to control the iceberg, and deliver more than half of it to the latitude of Adelaide or Perth. With the right equipment, the overall cost would be around $1¢/m^3$ of water, which is low compared with the present cost to Adelaide of municipal water (over $10¢/m^3$).

How do we melt the ice?

The iceberg has such a deep draught (around 200 m) that it cannot approach much closer than the edge of the continental shelf. We need to choose a point where the shelf is narrow, and the processing must be done out at sea. If we choose to do the melting at sea, we can surround the berg with an impervious barrier to catch the fresh water as it melts and floats on the heavier sea water. This method is liable to severe seawater contamination. Another way is to speed up the absorption of the sun's heat on the top surface with some black material, and catch the water before it drains off the iceberg. The yield of water is likely to be low with this method. Either way, the water must be pumped ashore.

A method which shows more promise is to break up the icebergs into large lumps which can be towed right into shore and handled by some shore-based facility into a melting pond.

The Environmental Challenge.

The use of iceberg water has some environmental costs. The only significant ones would be at the point of use, where a melting iceberg would give rise to a buoyant plume of fresh water, and a grounded iceberg would plough up the sea bottom. These effects would be very small compared with the impact of, say, a seawater desalination unit, which must discharge large quantities of more saline water close to shore.

On the other hand, iceberg water offers some positive environmental benefits, if the right approach is taken towards its use. This is because it is like no other source of water that we are familiar with, being very pure, and potentially available at the times and in the quantities that we desire.

Normal water supplies involve very considerable environmental costs that we have accepted as inevitable, but which in some cases involve the virtual destruction of a river system as a living system, and a self-sustaining entity. The use of partly saline water for irrigation has exacerbated soil salting and downstream salinity. New urban centres on river basins further threaten the health of the downstream eco-systems through pollution.

Iceberg water could contribute to the alleviation of such problems through the replacement of conventional supplies, to allow the natural systems to be re-established. Pure iceberg water can be used for irrigation without the risk of soil salting, and could supply coastal urban growth centres without great pollution risks.

Iceberg water should have a place in the twenty first century.

Mr. Job asked for questions from the audience and added the following comments.

It will take about 20 million watts (or 20 thousand horse-power) to tow an iceberg, at a speed of about 1 knot.

The underside of an iceberg is usually assumed to be "bumpy." Nobody knows in detail what it looks like, and investigations are in progress.

A pipeline all the way from Antarctica would be an expensive way to get water. Pumping would cost about 60 times as much as towing icebergs. Furthermore, the icebergs would be much harder to melt down there.

Several tugs at least would be required to tow an iceberg. The tow lines suitable for the job are not yet available. A submarine, with a spike attached, has been suggested. The Rand Corporation has dreamed up a floating nuclear power station with many propellors attached. It may be possible to collect icebergs from near the northern limit of their range, saving a long haul from Antarctica. They would probably be too hard to find there, though.

Some use may be made of westerly winds in moving icebergs towards Australia. The winds would not be reliable and strong towing would still be necessary to control the iceberg.

The Murray Canyon is too far offshore to be used as a dry dock for landing icebergs.

The flow in the Murray River would be increased by using iceberg water in the valley. This will not itself be an environmental problem because so much of the natural flow is lost through irrigation now.

There is no risk of a population explosion if the water supply from icebergs is considered as a means of better using the environment. Some agricultural land can be improved and the rest released on recreation and wilderness areas.

(Questions and answers taken down by R.J. Whatmough.)

CLIMATIC NORMALS ARE INEFFICIENT

by Arnold Court

(Professor of Climatology, California State University,
Northridge CA, USA)

1 PREFACE

Normals are the most consecrated canons of climatology. They are carefully computed according to a rigorous ritual and reverently bestowed, by ordained climatologists, upon those pious places at which the original observations meet saintly standards of holy homogeneity. They are presented liturgically to neophytes and laymen, in response to supplications of all sorts.

At the risk of censure or even excommunication, I intend to demonstrate here that climatic normals are inefficient and inappropriate for the primary use to which they are put. They may be holy relics of quondam conditions, but they possess poor potency for prediction.

2 NORMALS

Normals are senescent survivors of the classic and comfortable concept of climatic constancy. Until the last century, hills were everlasting, biologic species were immutable, and "climate" was the fixed value about which weather conditions varied randomly. Since these accidental variations would balance out in time, an average taken over many years would offer an approximation to the "true" climate.

Until about 40 years ago, climatic normals were simply the average of all the observations, the more the better. The standard error of the mean of k independent observations on a fixed but unknown quantity has been known for more than a century to be

$$s_{\bar{x}} = s_x \Big/ \sqrt{k}$$

where s_x is the standard deviation of the individual observations about their true mean. Hence, as an estimate of the "true" climatic mean, a 100—year mean should be twice as precise as a 25—year mean. Many people have calculated the number of years, k, on which a mean must be based for its standard error to be less than some desired value, such as half a degree.

However, during the present century the assumption of an invariant climate, subject only to independent random fluctuations from year to year, has been replaced by the realization that climate fluctuates over the decades, centuries, and millenia. (Landsberg, 1955). Such fluctuations cause the standard deviation of a climatic element to increase with the length of the record. The standard deviation is increased also by changes in instruments and their exposures, and in methods of observation and summarization. In addition, serial dependence from year to year may cause the standard error of the mean to decrease more slowly than by $1 / \sqrt{k}$.

To reduce the effects of fluctuations on climatic normals, the International Meteorological Organization in 1935 recommended that normals be based, not on the entire period of record, but on the 30 years 1901-1930. Two decades later, its successor, the World Meteorological Organization, adopted this definition:

> Climatological standard normals: Averages of climatological data computed for consecutive periods of 30 years, the first of which started on 1 January 1901.

Averages for any other set of "at least three consecutive 10-year periods" are called normals, and averages "for any period of at least ten years starting on 1 January of a year ending with the digit 1" are period averages. (Maher, 1966).

Since adoption of the 30-year climatological standard normal, many studies have been made of its "representativeness" and other properties. Significant differences have been found between successive 30-year normals, and between such normals and the classic period-of-record averages. Other investigators have examined how closely the mean of k successive observations, not limited to $k = 30$, approaches the mean of a longer period including those k years.

3 PREDICTION

Describing the past climate, however, is not the primary use to which climatic normals are put. Description of conditions during specified periods is of value only for the study of climatic variations from period to period, and for comparisons either with similar normals from other places or with other phenomena, such as plant distribution or disease incidence. Even such comparisons, among which climatic classification is a common example, are largely for extrapolation: they are assumed, implicitly, to apply beyond as well as during the period, for which computed.

In most applications, normals or other averages are used to predict future conditions. The predominant use of a climatic normal is for estimating the crops that can be grown, the fuel that will be required, the water that will be available, the clothing that will be worn, the transportation interruptions that will occur, or any of the manifold likely effects of weather on man's diverse activities and interests. Such applications may be for next year only, or for the next decade, or even for the entire next century, in the case of large water projects.

How well did the climatological standard normal (1931-1960) estimate this year's temperature, last summer's rainfall, this month's sunshine? Would an average for some other period, such as the last 10 or 20 years, have done better? Before such questions can be answered, a verification standard must be established, analogous to that for other forecasts. Only two criteria seem acceptable: mean square error and mean absolute error. Their relative merits could be discussed at length, but for the present mean square error, or prediction variance, will be used; later, some comparisons with mean absolute error will be offered.

Discussion of a time series of n climatic observations involves three intervals: the number, k, of antecedent observations from which a mean (or other statistic) is computed, the length, ℓ, of the future period for which the mean (or other statistic) is to be estimated from that for the k years, and the "lag," m, between the two periods:

The prediction or extrapolation variance, $S^2_{k\ell m}$, in using a k-year average to estimate an ℓ-year average beginning m years later is computed, from a series of n observations x_i ordered in time from x_1 to x_n, as

$$S^2_{k\ell m} = \frac{1}{n-k-\ell-m+2} \sum_{i=1}^{n-k-\ell-m+2} \left[\frac{1}{\ell} \sum_{j=m}^{m+\ell-1} x_{i+j+k-1} - \frac{1}{k} \sum_{j=0}^{k-1} x_{i+j} \right]^2$$

Its square root, $S_{k\ell m}$ is the standard error of extrapolation. The mean prediction error, $Q_{k\ell m}$, is obtained by taking the absolute value, rather than the square, of the difference. Instead of the k-year mean, the median value for the k antecedent years may be used by the estimator. The mean prediction error of the median, $D_{k\ell m}$, is defined analogously as the mean of the absolute difference between the k-year median and the median value for the m years beginning ℓ years later.

How well a k-year average of a given climatic element will predict the value of that element m years later was studied by Brier [1955], Beaumont [1957], Enger [1959a], Craddock and Grimmer [1960], and Drozdov et al. [1965]. All except Drozdov et al. investigated prediction of single values, rather than ℓ-year means, so that $\ell = 1$. All except Enger and Drozdov et al. estimated only next year's value, the k + 1st, so that $m = 1$.

All investigators were interested primarily in finding the value of k for which $S^2_{k\ell m}$ (or $S_{k\ell m}$) or $Q_{k\ell m}$ was smallest. This minimizing of k will here be denoted as k* ("k-star"). Implicitly, in the previous studies k* was assumed to indicate the "optimum length of record" for prediction. Drozdov et al. used the mean absolute difference $Q_{k\ell m}$, all others used $S^2_{k\ell m}$ or $S_{k\ell m}$. Medians have not been studied in any previous investigation.

4 SIGNIFICANCE

In random sampling from a normal population with mean 0 and variance 0^{-2} , a k-element mean, $\bar{x}_k$, is normally distributed with mean 0 and variance $0^{-2}/k$. The difference of two independent normal variables also has a normal distribution, with mean equal to the difference of their means and variance equal to the sum of their variances. Hence the difference between one observation and a k-element mean, not including it, is normally distributed with mean 0 and variance $0^{-2} + 0^{-2}/k$.

Thus, in random sampling from a normal population, the mean square difference between a k-year mean and the population mean decreases as $1/k$, Eq. (1) , while the mean square difference between a k-year mean and a random single value (not included in the k years) decreases as $1 + 1/k$. The standard error of extrapolation, S_k , is $k + 1$ times the standard error of the mean:

$$S_k = s_{\bar{x}} \sqrt{k + 1} = 0 \sqrt{1 + 1/k}$$

These relations offer a first approach to assessing the significance of the behaviour of S^2_k with increasing k . If S^2_k decreases more rapidly, for some range of k , than $1 + 1/k$, a minimum may represent more than a "random number taken from random data" [Von Hylckama, 1958]. To provide a visual indication of the behaviour of S^2_k compared to $(1 + 1/k)\, 0^2$, curves of the theoretical relation have been added to all graphs of $S^2_{k\ell m}$, with 0^2 taken as equal to 1, 2, 3, ... or 10, 20, 30, ... at k = 50 , so that the curves become horizontal at k = 50.

Since the "true mean" is assumed to be constant, this relation should not depend on m, the separation between the k years and the year for which the estimate is made. But it does depend on ℓ, the length of the period to which the forecast is applied, if $\ell > 1$. The difference between a k-element mean and an ℓ-element mean is normally distributed, under the previous assumption, with mean 0 and variance $(1/k + 1/\ell)\, \sigma^{-2}$. When a k-year mean is used as a predictor of the mean of another k-year period, the extrapolation variance is $2\, \sigma^{-2} / k$, twice the variance of either mean with respect to the "true" climatic value.

These relations are based on the assumption that the "true mean" is constant, and that individual observations all have the same variance about it. That is, they assume that the sequence of observations forms a stochastic time series that is stationary in both first order (for mean) and second order (for variance). Actual climatic data, however, may violate one or both of these assumptions. Means may be changing with time, either slowly or by jumps, and so may variances. These changes may be either natural, true climatic changes, or they may be observational, arising from changes in the instruments used and their exposures, as well as in the manner of reading and procedures for summarizing those readings.

5 EXAMPLES

In 1966-1969, under a small research project supported by the Air Force Cambridge Research Laboratories, more than six thousand values of extrapolation variance, $S^2_{k\ell m}$, were computed, and more than a thousand each of $Q_{k\ell m}$ (absolute difference from antecedent mean) and of $D_{k\ell m}$ (absolute difference from antecedent median). These were for monthly and annual temperature, precipitation, days with rain, and percent of sunshine. Results were presented in five reports; only a tiny sample can be presented here.

One set studied extensively was for seven stations in central and eastern United States, the ones with the longest records, about 80 years each, appearing in World Weather Records for North America, 1951-1960. They are not the U.S. stations with the longest or best records, but are merely arbitrary examples of good, clean, acceptable stations, perhaps a little better than most of the weather stations for which normals are computed routinely.

Figures 1 and 2 present the annual temperature and precipitation values, year by year, for each station, and graphs of S_k^2 for k running from 1 to 50 years; since both ℓ and m are one (prediction is for the k + 1st value), these subscripts are omitted. While k^*, the number of antecedent years giving the minimum variance estimate of the next value, varies from 10 to 21 years for temperature and from 4 to 48 years for precipitation, clearly 30 years has no special merit. None of the 14 annual series shows any significant serial correlation, at any lag.

Figure 3 presents S_k^2 for annual temperature in four long records, and separately for each half of three of them. Figure 4 shows results for the number of rainy days, by months, at Woodstock MD, a climatological benchmark station studied extensively by Landsberg, Mitchell, and Crutcher [1959], who generously provided copies of the punch cards. Figure 5 gives similar results for the percent of sunshine, by months, at Boston, tabulated for a study by Lund [1966], who furnished the basic data on magnetic tape. In all three figures, the patterns seem bewildering: some of the S_k^2 curves follow the theoretical lines reasonably well, some plunge more steeply, and some reach a rather sharp minimum and then increase.

Possible explanations for this erratic behaviour can be found in the behaviour of S_k^2 computed from random numbers biased in various ways. Sets of 100 or 1000 random numbers were divided into thirds or fifths, successive segments were then increased by one unit, biasing the means to make a stair-step sequence; alternatively, the segments were inflated progressively, so that they had the same means but increasing variances. The stronger the bias in the mean the faster the S_k^2 curves rose as k increased; contrariwise, biasing the variances caused the curves to descend more and more steeply, making k^* come later and later with increasing variance bias.

These findings suggest that many climatic records contain slight shifts in mean or variance. These may be true climatic changes, or they may be the result of changes in instruments, exposures, or observational practices. Whatever their nature, these changes produce climatic records in which, in general, the minimum variance estimate of next year's value is the mean of far less than 10 antecedent years.

When S_k^2 is computed separately for each month at one station, little similarity in behaviour is found in consecutive months: values of k^* vary markedly from month to month. But at nearby stations the curves for the same month often are similar, with k^* the same at the two places, because correlations of monthly temperature or precipitation at stations less than 250 km apart is higher than that from month to month at any one station. Thus the extrapolation variance S_k^2 appears to depend strongly on the actual sequence in which weather occurs over the years, and to be far more sensitive to fluctuations, or occasional "abnormal" years, than are other measures, such as variance, serial correlation, or the spectrum.

6 EXTENSIONS

Means of past observations are not the only possible predictors of future events, and mean square differences not the only measures of prediction precision. The median of k antecedent observations may be a better predictor than is their mean; for the 7 U.S. stations (Figs. 1 and 2) it is. In almost two-thirds of the station months studied, the smallest mean absolute difference from the k-year median was less than the corresponding minimum difference from the mean. In most cases, the optimum number of years, k^*, was the same for the median as for the mean.

The most puzzling result of the investigation appears when a k-year mean (or median) is used to predict more than one year ahead. Extrapolation variances, $S_{k,m}^2$, for $m = 2, 3, \ldots, 10$ years ahead formed, for a given month at a single station, curves which were very similar in shape -- but displaced one year to the left for each additional year of extrapolation. Usually the minimum variance estimator of a value m years ahead was based on an averaging period $m - 1$ years <u>less</u> than the value for one year.

Apparently, each climatic series has some sort of natural period of homogeneity. Optimum prediction results when all computations are confined to this interval. Thus the antecedent period for prediction m years ahead is $m - 1$ years shorter than for one year ahead.

The final extension of the study involves ℓ, the number of future years for which the average is estimated from a "normal." Comparison of the k-year mean with the mean for the following 10 years ($\ell = 1$ and $m = 1$) gave results generally similar to those for predicting a single value 5 years ahead ($\ell = 1$ and $m = 5$).

7 CONCLUSIONS

The major conclusions of this research are:

1. Most climatic series, even those adjudged to be completely homogeneous, contain changes in mean or in variance.

2. These shifts cause the series to have a homogeneity period which restricts the antecedent length of record on which extrapolation should be based.

3. Lengths of these homogeneity periods vary from month to month and from element to element at a single station, but tend to be similar, for a given month and element, at nearby stations.

4. While the lengths vary, many of them are much less than the customary 30 years used for climatic normals.

5. The median value of an antecedent period is a somewhat better predictor, because it has a smaller absolute error, than the mean.

These conclusions obviously lead to the suggestion that

> The concept of climatic normal should be abandoned in practical climatology. Instead, median values of 15-year periods should be computed every five years, to be published and used in the manner in which normals have been misused heretofore.

Fifteen years has been chosen as a compromise value. The number of years should be odd, so that the median may be found unambiguously. Climatic conditions often must be estimated for a time several years beyond the last year used in a readily available average, which itself may be a few years old. If the average extrapolation lag is 10 years, use of a 15-year median would presume a nationwide, or world-wide, homogeneity period of about 25 years. If anything, therefore, 15 years may be too long, and 11 or even 7 years may be found to be more suitable.

In conclusion, a suggestion about climate itself is offered. What is the climate that changes, fluctuates, and has relatively short homogeneous periods? Certainly it isn't the totality of weather over many years, or anything similar. Yet one cannot speak of the climate of a day, or an individual year.

So "climate" should be defined as the totality of weather conditions during a few years, certainly less than 30, maybe less than 15. Perhaps the alternation of seven years of plenteousness and seven years of dearth, which afflicted Egypt as Joseph had foretold from the Pharoah's dream (Genesis 41), is somewhat characteristic: seven years may be a suitable period for defining climate.

8 REFERENCES

Robert T. Beaumont, 1957: "A Criterion for Selection of Length of Record for a Moving Arithmetic Mean for Hydrologic Data." Trans. Am. Geophys. Un. 38:198-200.

Glen W. Brier, 1955: "Statistical Methods in Meteorology" (abstract). J. Am. Stat. Assn. 50:569.

J.M. Craddock and M. Grimmer, 1961: "The Estimation of Mean Annual Temperature from the Temperatures of Preceding Years." Weather 15:340-348.

O.A. Drozdov et al., 1965: (Problems of the optimum length of the period of averaging in climatological investigations). Trudy Glavaia Geofiz. Obs. imeni A.I. Voeikova 181:14-45.

Isadore Enger, 1959a: "Optimum Length of Record for Climatological Estimates of Temperature." J. Geophys. Res. 64:799-787.

Isadore Enger, 1959b: "Singularities in Daily Temperatures". J. Met. 16:238-243.

T.E.A. von Hylckama, 1958: "Discussion of Beaumont". Trans. Am. Geophys. Un. 38:198-199.

H.E. Landsberg, 1955: "Weather 'Normals' and Normal Weather." Weekly Weather and Crop Bulletin, U.S.W.B., 31 Jan 1955; revised version environmental data service (bimonthly) Oct 1972 pp 8-13.

H.E. Landsberg, J.M. Mitchell, Jr., and H.L. Crutcher, 1951: "Power Spectrum Analysis of Climatological Data for Woodstock College, Maryland." Mon. Wea. Rev. 87:283-298.

Iver A. Lund, 1965: "Indications of a Lunar Synodical Period in United States Observations of Sunshine". J. Atmos. Sci. 22: 24-39.

J.V. Maher, 1966: "Climatological Normals". Aust. Meteorol. Mag. 14:30-38.

Fig. 1. Annual Temperatures at 7 U.S. stations, by years (a), and S_k^2 (b).

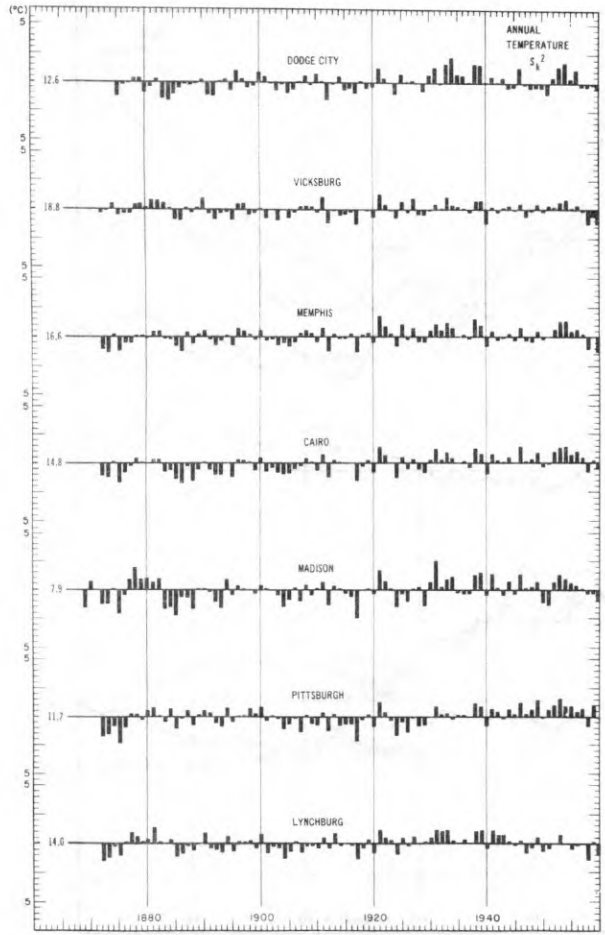
Fig. 2. Annual Precipitation at 7 U.S. stations, by years (a), and S_k^2 (b).

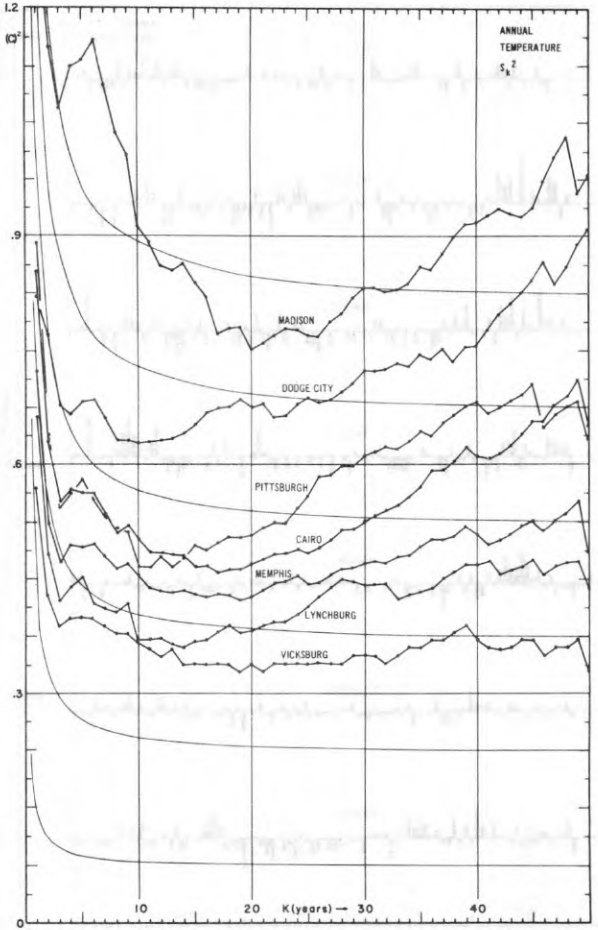
Fig. 3. Extrapolation Variances, S_k^2, at 4 stations, for entire record (a) and by halves (b).

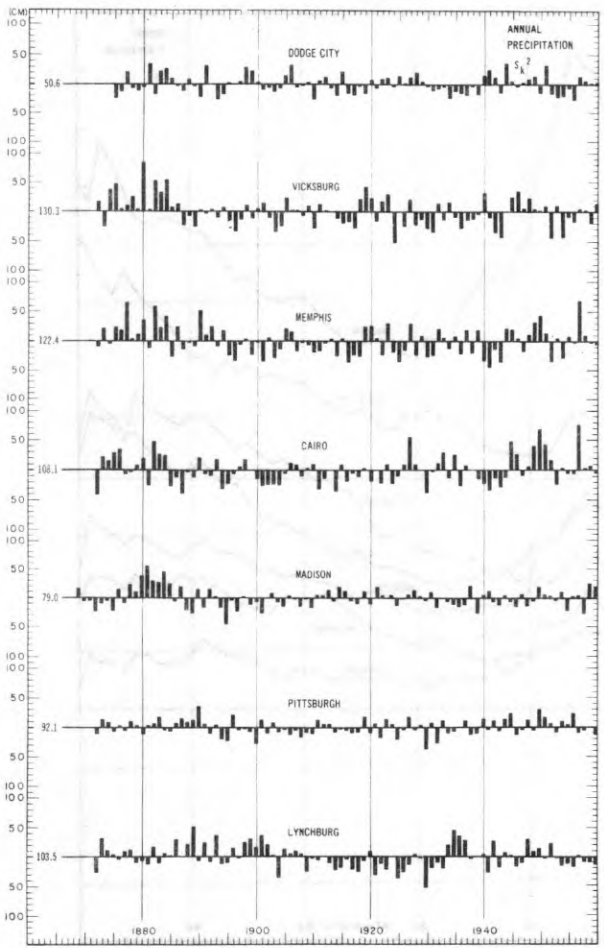
Fig. 4. Rain Days, by months, at Woodstock, MD.

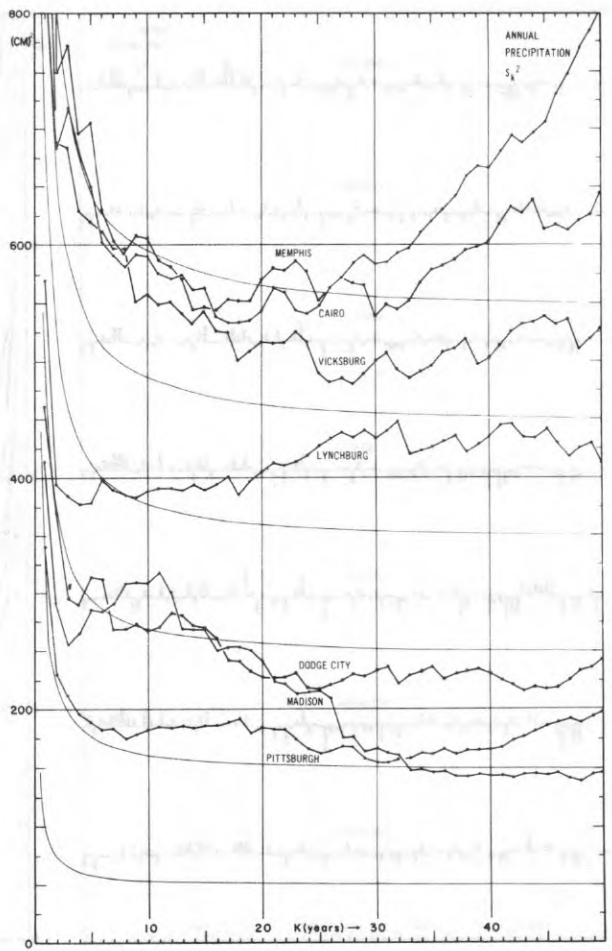
Fig. 5. Percent of Possible Sunshine at Boston, MA, by months.

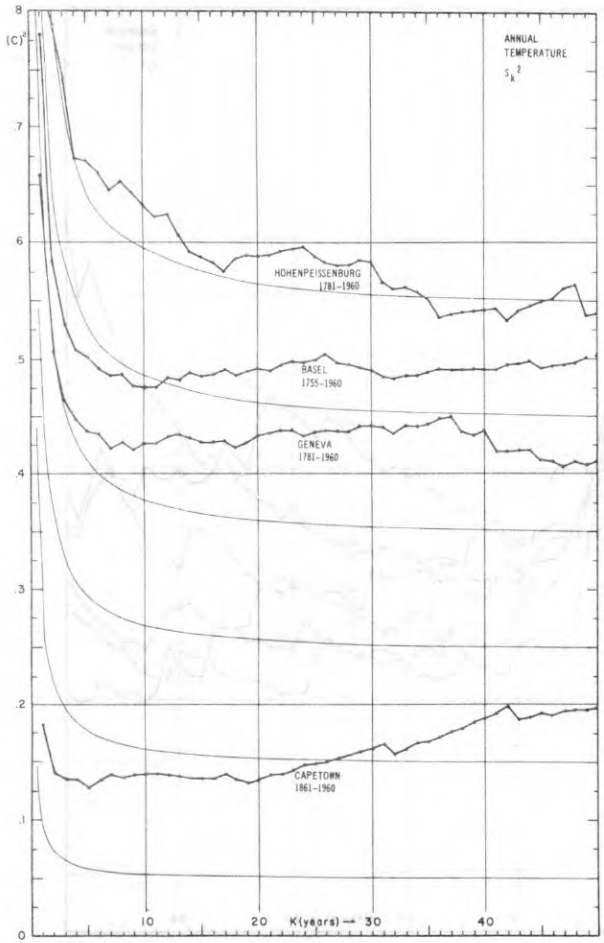
*Summary of talk to Australian Meteorological Association, Adelaide, S.A., 7 Sep 1972; longer version read 31 Oct 1968 in Asheville NC at Conference and Workshop on Applied Climatology of American Meteorological Society.

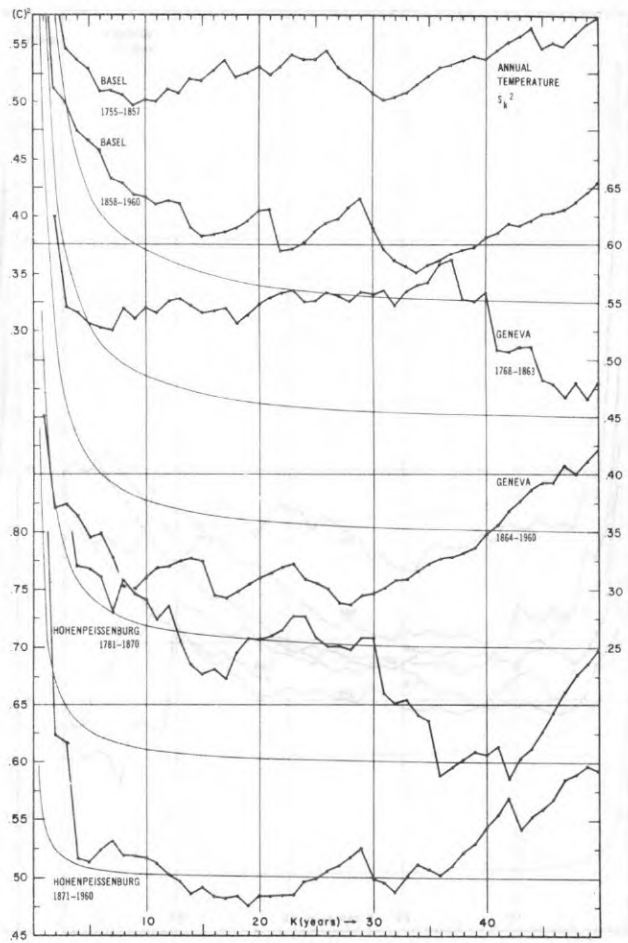

(°C)
ANNUAL
TEMPERATURE
S_k^2
DODGE CITY
12.6
VICKSBURG
18.8
MEMPHIS
16.6
CAIRO
14.8
MADISON
7.9
PITTSBURGH
11.7
LYNCHBURG
14.0
1880
1900
1920
1940

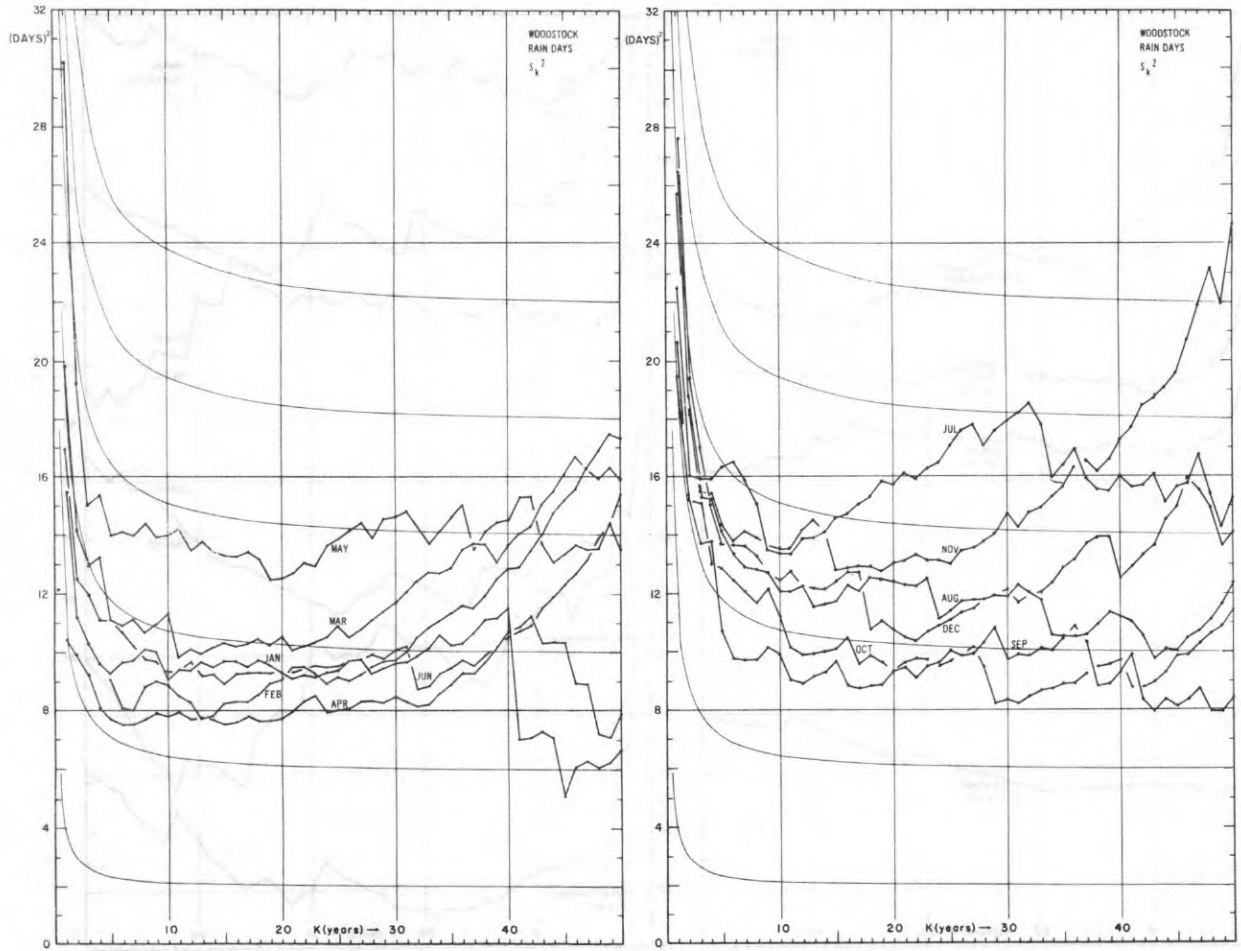

$(°C)^2$
1.2
.9
.6
.3
0
ANNUAL
TEMPERATURE
S_k^2
MADISON
DODGE CITY
PITTSBURGH
CAIRO
MEMPHIS
LYNCHBURG
VICKSBURG
10
20
K(years) →
30
40

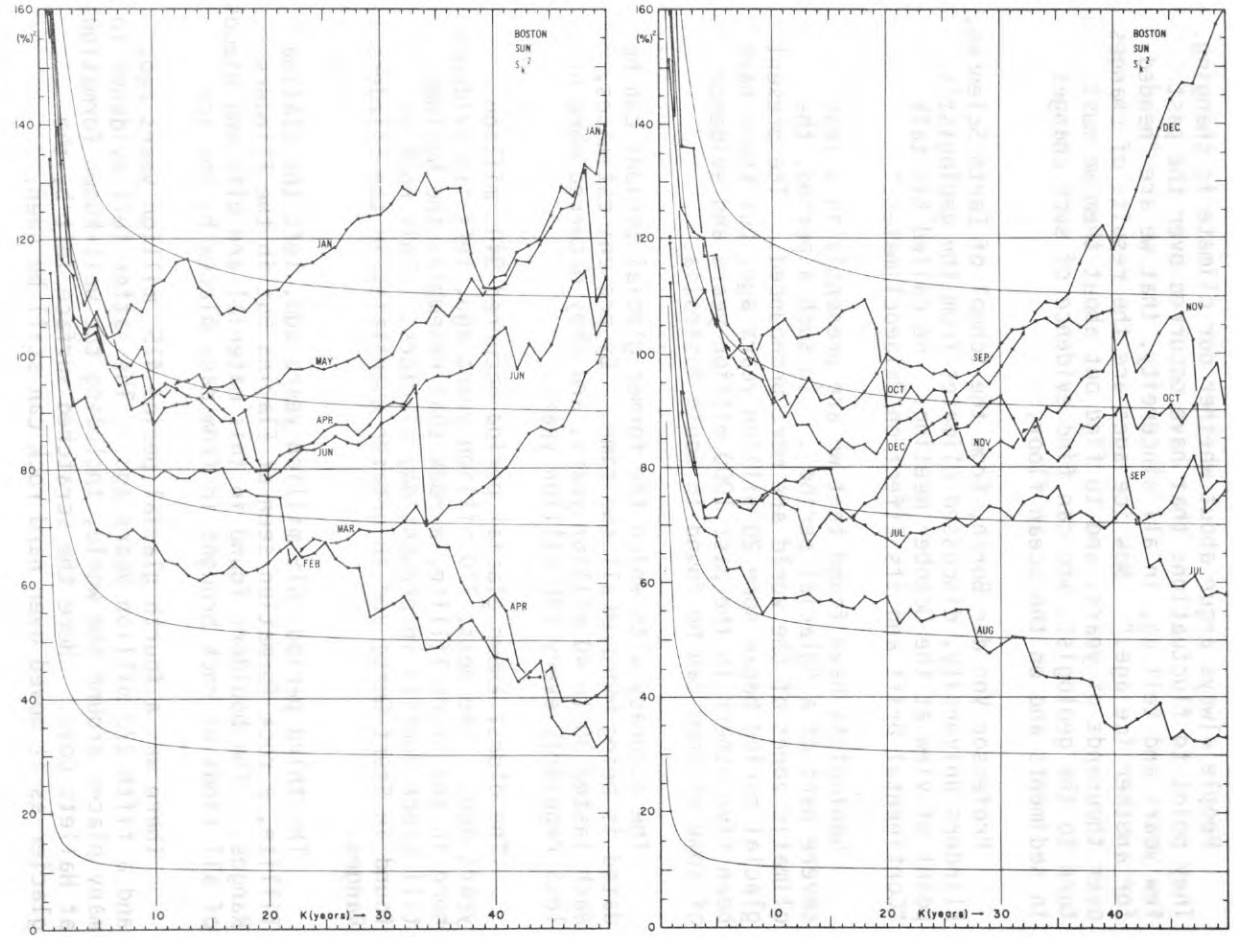

(CM)
ANNUAL
PRECIPITATION
S_k^2
DODGE CITY
50.6
VICKSBURG
130.3
MEMPHIS
122.4
CAIRO
108.1
MADISON
79.0
PITTSBURGH
92.1
LYNCHBURG
103.5
1880
1900
1920
1940


800
(CM)
600
400
200
0
ANNUAL
PRECIPITATION
S_k^2
MEMPHIS
CAIRO
VICKSBURG
LYNCHBURG
DODGE CITY
MADISON
PITTSBURGH
10
20
K(years)→
30
40


(C)²
ANNUAL
TEMPERATURE
S_k^2
HOHENPEISSENBURG
1781–1960
BASEL
1755–1960
GENEVA
1781–1960
CAPETOWN
1861–1960
K(years) →


(C)²
ANNUAL
TEMPERATURE
S_k^2
BASEL
1755–1857
BASEL
1858–1960
GENEVA
1768–1863
GENEVA
1864–1960
HOHENPEISSENBURG
1781–1870
HOHENPEISSENBURG
1871–1960
K(years) →


WOODSTOCK
RAIN DAYS
S_k^2
(DAYS)^2
32
28
24
20
16
12
8
4
0
10
20
30
40
K(years) →
MAY
MAR
JAN
JUN
FEB
APR
JUL
NOV
AUG
DEC
SEP
OCT


BOSTON
SUN
S_k^2
(%)^2
160
140
120
100
80
60
40
20
0
10
20
30
40
K(years)
JAN
MAY
JUN
APR
JUN
MAR
FEB
APR
BOSTON
SUN
S_k^2
(%)^2
DEC
NOV
SEP
OCT
DEC
NOV
OCT
SEP
JUL
JUL
AUG
10
20
30
40
K(years)

CONTINENTAL DRIFT AND ITS EFFECT ON PALAEOCLIMATES

Prof. Von der Borch.

People always argue about whether our climate is changing. They point to fluctuations that have occurred over the past few years and tell us, in all sincereity, that we are "headed for another ice age." Now ice ages are the results of changes over thousands of years, and to find out about them we must turn to the geologist, who can find evidence of such changes in sediments and on the ocean floor.

Professor Von der Borch, from the School of Earth Sciences, Flinders University, discussed climates from the geologist's point of view at the October meeting. He called his talk "Continental Drift and its Effect on Palaeoclimates."

Geologists have found that we are presently in a less severe part of a "glacial period". In such a period, the climatic zones of the world are more pronounced. The present glacial period began some 20 million years ago, but there have been five others in the past 1000 million years and evidence of some of them can be found in South Australia.

The accuracy with which the former glacial periods can be dated is being improved all the time. By present estimates, each lasted 30 to 40 million years, and they occurred more or less regularly every 190 million years.

The oldest known glacial period occurred 940 million years ago. The next, 770 million years ago, left its evidence here in the Sturt Tillite, a rock that resembles the boulder till (rock debris) in present day glaciers. This rock is found in Sturt Gorge and in greater quantities in the Flinders Ranges.

The third period, 615 million years ago, left the Elatina Tillite, a rock formation seen at Elatina Hut in the Flinders Ranges. The boulders found in this material are bits and pieces of all kinds of rock brought in from many places by the ice.

There was a fourth glacial period 415 million years ago, and a fifth 270 million years ago. The latter left evidence in many places around the world, including the well-known formations at Hallett Cove. Here the scratched surface left by the glacier as it moved over hard rock can still be seen.

Within a glacial period, the climate is not steady - it shows many rapid fluctuations, from "ice age" to quite moderate conditions. In looking at the evidence of the period in progress, we see the traces left by several colder phases within it. Most of these traces are found in the Northern Hemisphere, where glaciation was extensive. In the south there was much less glaciation, but some can be seen in the Australian Alps.

The evidence of climatic fluctuations within the present glacial period is not confined to glaciation. In Death Valley, USA, there are old shorelines, formed by a lake 15 to 20 thousand years ago.

In the Flinders Ranges the evidence of past climates is quite strong. The large alluvial fans along the western foot of the ranges could not have been formed by the present streams. There must have been mud flows metres thick running for several kilometres onto the plains. In Blackfellows Creek near Hawker, two old mud flows can be seen. The mud carried boulders with it as it went - such flows are seen today in the Andes, where they have buried whole villages, but not in the Flinders Ranges.

The climatic history of the alluvial fans has been reconstructed. From 38 to 30 thousand years ago, the climate was cold and generally arid but with intermittent strong rainfall. The fans were built in these times. A cold, arid and windy period followed until 16 thousand years ago, causing erosion of the alluvial fans and the formation of sand dunes. There was another warm, humid period up to 12 thousand years ago, and others 6 to 5 thousand years ago and 3 to 2 thousand years ago.

As the climatic variations in a glacial period cause ice to form and disperse, sea levels rise and fall. There are plenty of good indications of such changes. R.W. Fairbridge (see "The Changing Level of the Sea," Scientific American, May 1960) published sea level curves which go back 400 thousand years and show a general falling trend with strong fluctuations that correspond to the severe and moderate climate phases. His curves have now been corrected - and fluctuations he showed were correct but the falling trend has been discounted.

In the presently accepted curves, the sea was at its present level 120 thousand years ago, but below it between then and now. There have been fluctuations of 100 to 200 metres over the 400 thousand year period and the level is now near the top of such a fluctuation, having risen from 100 metres below present level in the last 20 thousand years. If the remaining polar ice melted, the level would rise another 50 metres relative to the land (this allows for a sinking of the land under the weight of the extra water!).

In the South-East of South Australia there is an extensive set of sand dune ranges. These ranges run in parallel lines at an angle to the general slope of the land; each is like the present Younghusband Peninsula. They are the combined result of slowly rising land and fluctuating sea level. An extensive program of drilling in the area is yielding a detailed history of the ranges - one at Naracoorte seems to go back 2.9 million years!

The low sea level 20 thousand years ago left much evidence off the South Australian coast. It affected the shape of coastal cliffs as at Wedge Island and produced submarine canyons, including one some 1300 fathoms deep near the Murray Mouth.

Continental drift, the movement of the continents on the surface of the earth, was first suggested by A. Wegener many years ago. He was laughed at in his day but plenty of evidence to support him has now been found on the ocean floor.

The earthquakes of the world are concentrated in distinct belts. Between these belts are large stable areas, called "plates", which are in relative motion. Where the plates move apart, there are mid-ocean ridges where fresh molten rock moves in to fill in the cracks. Where the plates move together, one is forced below the other and is destroyed. The continents are carried on these plates. The pattern of plates can change, and continents can be broken up and recombined. Thus Africa and the Americas were once a single land area and, 40 million years ago, Australia was joined to Antarctica.

Because the ocean floor is being destroyed in some places and renewed in others, it is hard to find any part that is very old geologically. The oldest part of the Pacific, for example, is near Japan - it formed only about 200 million years ago, at the mid-ocean ridge now found near North and South America. There are other oceans that have closed up and disappeared altogether!

The Earth's magnetic field has a measurable effect on some rocks as they form. By measuring this effect in old rocks, the geophysicist can work out the direction of the field and the positions of the magnetic poles in times past. The movements of the continents about the geographic poles can then be deduced. Such movements are a possible explanation of the long term glacial periods. At present, the South Pole is in a large land mass and the North Pole in a land-locked ocean - this is an unusual arrangement in a world of drifting continents and it must be having a strong effect on the present climate.

Recent papers offer an alternative cause for glacial periods, by relating them to the movement of the Solar System through the galaxy. But the field is still young .....

The latest sea level curves have been constructed by finding old coral beds and then measuring their ages by comparing the concentrations of the small amounts of uranium and thorium in them. This method gives information for the last 200 thousand years. Mean temperature curves for each latitude over this time can be found by calculating how much the earth precesses (or wobbles as it spins). The results are in good agreement - the sea level has risen and fallen in the same way as the temperature, but has lagged behind it by 2 to 7 thousand years. These fluctuations are an adequate explanation of the rapid fluctuations of climate when a glacial period is in progress.

American scientific institutions are presently co-operating in a project, called CLIMAP, whose aim is to study the fine details of ancient climates and to predict future fluctuations. After all, another freeze could be just around the corner .....

(As taken down by R. Whatmough).

SURVIVAL IN ANTARCTICA

Our February 1976 meeting was the first held at the Australian Mineral Foundation building. In keeping with the novelty of the occasion (but not with the weather), our speaker Mr. George Hamm arrived dressed in a heavy parkha.

"Outside temperatures in Antarctica in February vary between 65°F and -35°F," he explained, apologising for his addiction to the Fahrenheit. "Husbands here who washed the dishes tonight just pulled the plug as they finished. If you did that in Antarctica, the water would freeze."

Mr. Hamm should know - he led several expeditions to Antarctica, his most recent ending about 3 years ago.

Survival in Antarctica is certainly a problem. Mr. Hamm's last expedition left with 32 men and came back with only 30. The greatest hazards are, of course, cold and wind, and to protect the men, expensive clothing is needed - at $2000 an outfit. Even the clothing and tents are not enough, though. Warmth requires good food, as Scott found out the hard way.

The most conspicuous part of the Antarctic-style parkha is the hood, lined with the fur of the Canadian wolverine. Also conspicuous in Mr. Hamm's case were the seal blubber stains on his parkha - he fed the dogs.

We then saw a kitbag full of other items worn by the Antarcticans, often all at once. Standard dress includes heavy pants to match the parkha, a heavy string singlet, four layers of gloves, four layers of socks, two layers of shoes with three of linings, balaclava and goggles. Beards are essential in a land of running noses.

Gloves are a real problem. The outside pair are hung on a string around the body, and a spare pair are kept in one of the many pockets on the parkha. To use a theodolite, a surveyor must "strip down" to two layers, and risk freezing his hands in five minutes. His watch will freeze even sooner. Cameras often suffer the same fate.

With all their layers of clothing, expedition members can still suffer frostbite. Anyone found suffering from frostbite in the field is sent back to his tent immediately .....

Huskies are very much a part of Antartic life. Each has a personality of its own, and Mr. Hamm had many stories about their antics. Yellow stains on some of his clothing were a souvenir of the way that a husky shows his affection for his master. On one trip, when two food dumps had been missed, expedition members had to kill one husky for food. The dog chosen had a reputation as a trouble-maker in the team.

Everyone in an Antarctic expedition has a second occupation, to ensure that there is always someone who can stand in when one member is ill. Mr. Hamm's second job was assistant surgeon, and he took a medical course for the purpose. He saw some crude but necessary emergency operations, like the use of a carpenter's drill to remove a brain clot!

Mr. Hamm also specialised in fleas. In other places, fleas will run, hop, skip or jump according to the species. In Antarctica, the local fleas (known as Glaciophilis antarcticus) "walk with a wobble." They live on Snow Petrels, and in winter remain in the petrels' nests under the snow when all the petrels, penguins and seals have gone to sea. There was a tale of how some of these fleas were placed in acetone to prepare them for taking to a museum. They survived! Then there were the mosses found around Mawson, up to a thousand years old .....

Expeditioners cannot keep expeditioning without a chance to relax and stop brooding now and then. Although spirits are forbidden for safety reasons, beer is included in rations, and home brew is often brewed. At times there have been stronger preparations .....

Part of Mr. Hamm's job as expedition leader was to maintain relations with other Antarctic teams of many nationalities. He noted that relations with Russian and Japanese scientists are good - with the Americans, not so good. On one expedition, he visited and inspected a Russian base.

The Russians were a funny lot. Their whole organisation was based on rank. A man's rations, clothing, in fact, everything, depended on his rank. In the Australian team, the only difference between the ranks is the colour of the leader's parkha - his men have to be able to find him in a blizzard.

After the visit, the Russians insisted on flying Mr. Hamm straight back to the Australian base. Now Antarctica is a steep-sided, snow-covered plateau, and strong katabatic winds sometimes blow from 10 pm right through the night and morning to 2 pm. The Russians did not wait for the afternoon calm, but set out immediately and crash-landed in the tricky winds. There were no casualties, but the plane was a write-off.

The Russians sent out an ice-breaker to pick up their men from the plane. Several of them, including their captain, were invited ashore for an "official" party. They marvelled at the flip-top beer cans, a great change from vodka. The captain was then given a sample of a special Australian "ice-breaker" of apricot juice, somewhat diluted with medical alcohol. He took it in one gulp and sat down in a hurry ..... A return party was promptly given on the ship.

All was not well with the Russians, though. They had crashed their government's property and prospects for them back home were very grim. Could those on board be given sanctuary? Unfortunately there were far too many on the ship for that.

When Scott tethered his snow ponies by his hut in 1911, little did he know what effects he would have on the local wildlife in the distant future. Sixty years later, the wind blew away the snow from near the hut, exposing a dung heap as fresh as the day it was made. Unsuspecting Emperor Penguins partook of it. When the New Zealand team used the penguins in anti-haemophilia serum tests, they discovered that the whole colony had caught ..... tetanus!

Mr. Hamm had a special word for the meteorologists, of whom there were four in his last expedition. They are trying to work out whether the ice cover of Antarctica is growing or shrinking, and how useful a knowledge of the weather there is in long-range forecasting for Australia. Every three hours, however foul the weather, the "mets" would send up a radiosonde to take their observations. The data was sent off to the Weather Watch centre in Melbourne.

But even meteorology has its lighter side - once a year, the expedition holds the "Mawson Shoot". The target is a hydrogen balloon. And the prize is a can of beer - cold of course!

NEW REGIONAL OFFICE - BUREAU OF METEOROLOGY KENT TOWN - S.A.

Commencing with site seeking early in 1972 and progressing through the stages of land acquisition, environmental impact statements, functional briefs, 18 months of hard work at the drawing board and final acceptance of a tender, the new building now under construction at Kent Town, S.A. to house the S.A. Regional Office of the Bureau of Meteorology is fast taking shape. It comprises a 3-level L-shaped edifice of concrete frame construction, the contract price for which is $1,604,923.

Two large central towers contain, respectively, lift/stairwell and toilet/washroom facilities. The first of these will be capped by a glass all-weather astrodome for observational purposes. Two other smaller towers, one at either end of the building, serve principally as fire-escapes.

A mezzanine floor containing offices overlooks the Regional Forecast Centre and is connected by an overhead bridge to the lift tower and stairwell.

Outside, a sloping bridge leads from the corner of the building at Level 2 diagonally across and down to the instrument enclosure, providing ready transit by staff to the enclosure and giving the entire complex an air of integration.

On-site parking will be available for approximately 40 vehicles.

Construction is progressing well, as can be seen in the accompanying recent photo, taken at the Kent Town site.

The building is nearing completion; there will soon remain only the task of installation of communications and instruments, prior to organising the changeover from existing premises in West Terrace and Currie Street to the new building.

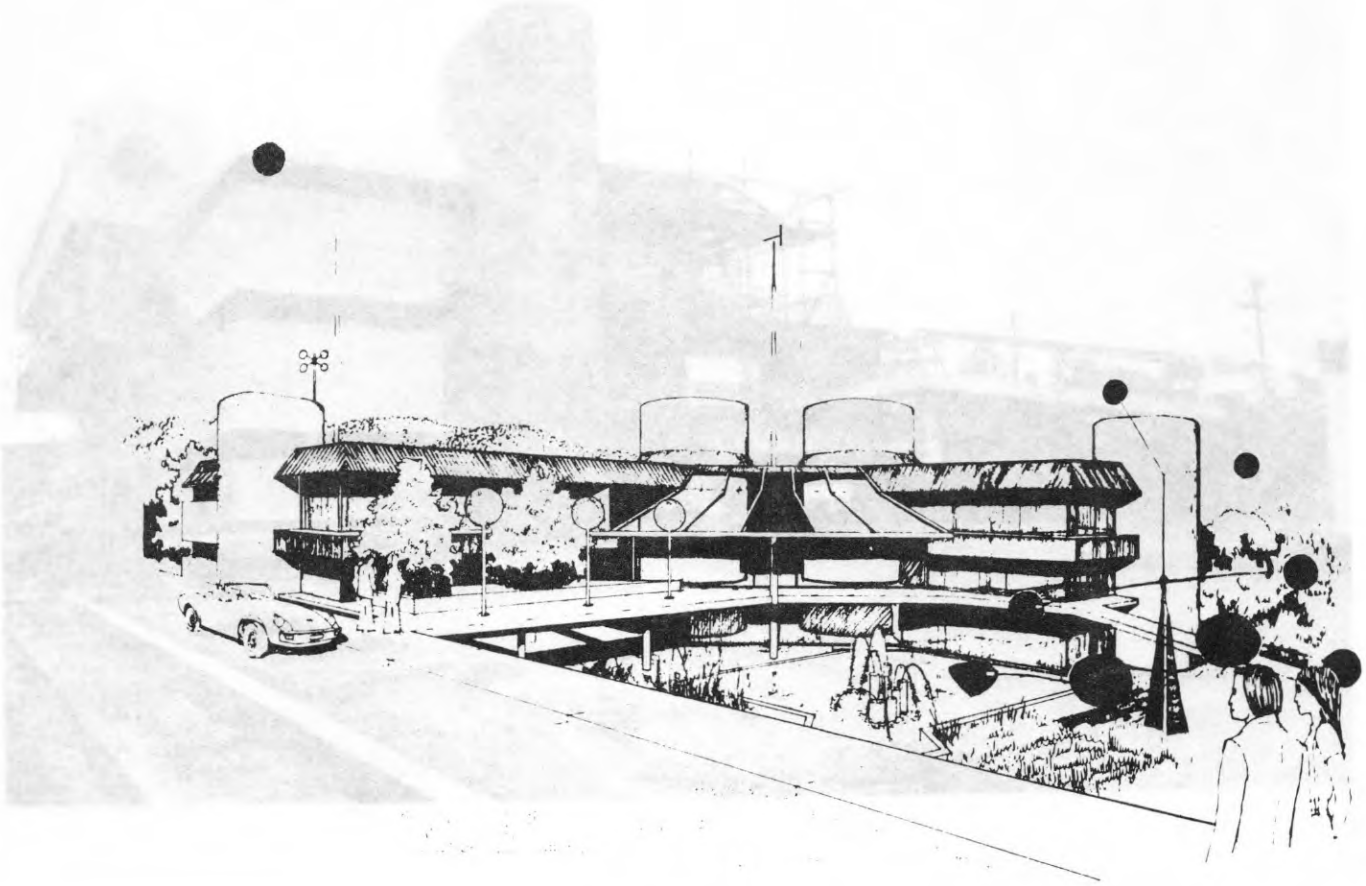
Inside, most partitions are now in place, painting is well in hand, the lift has been installed and carpet is about to be laid in Level 2.

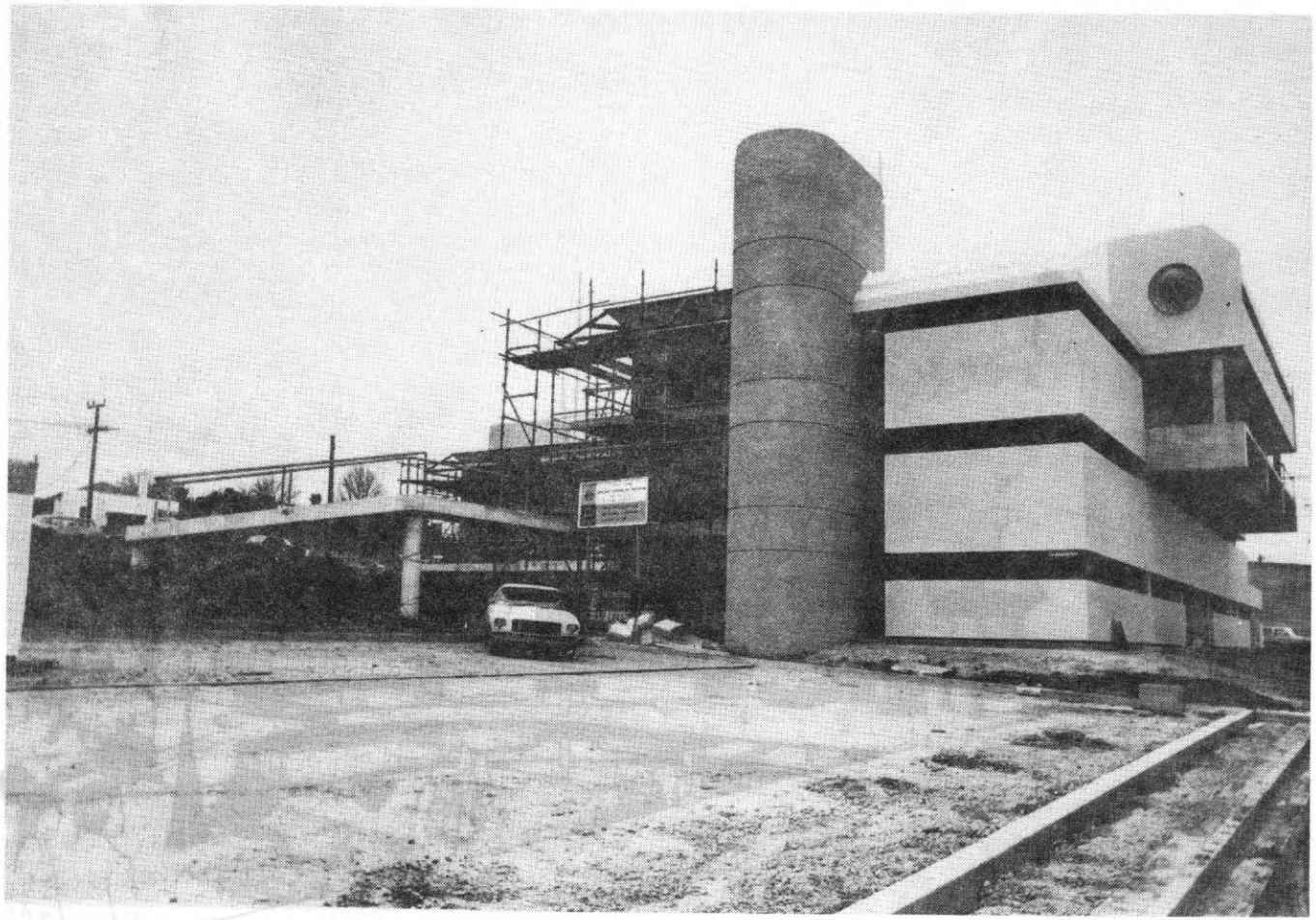
Outside, bulldozers are hard at work contouring the site and preparing the instrument enclosure. The car park has only to be sealed.

The building, with its elevated walkway and towers, is already attracting a lot of attention in the Kent Town area and it seems certain that the Bureau will receive many interested visitors when it moves in - a move which could yet take place by Xmas 1976!

L. Mitchell.

St. Peters College
RUGBY
BALIOL ST.
TRINITY ST.
COLLEGE ST.
PALM PL.
ATHELNEY AV.
BOTANIC
OSBORNE ST.
WESTBURY ST.
TCE. R.O.
NORTH
Rd.
Rd.
DEQUETTEVILLE
LIT. K. WILLIAM
KING WILLIAM
LIT. RUNDLE
RUNDLE
KENT
COLLEGE
ST.
LIT. GRENFELL ST.
GRENFELL ST.
LIT. DEW ST.
DEW
LIT. YOUNG ST.
YOUNG ST.
CAPPER
LIT. CAPPER ST.
Alfred
Prince
College
TOWN
PIRIE
LIT. FLINDERS
FLINDERS
LIT. WAKEFIELD ST.
WAKEFIELD ST.
LIT. ANGAS ST.
ANGAS ST.
WHITES ST.
BENDA
FULLARTON
ROAD
PAYNEHAM
Hotel HENRY
RGE
MAGILL
CHAPEL ST.
ROAD
EDMUNDS ST.
KING ST.
MATTINGLEY
BEULAH
CHARLOTTE RUNGE
PL.
FISHER
ST.
GRAY ST.
RAVENSWOOD
AV.
ROKEBY
EASTRY ST.
OXFORD PL.
THE
KENT
Rd.
MONTROSE AV.
BOSKENNA AV.
NORTH ST.
THRELFALL
WILLIS
COLLIVER
BENSON ST.
WILLIAM
CLEVE
GILBERT
JOHN ST.
CLARKE
CHARLES
SHEPPARD
DAVIS
STACEY
SYDENHAM
KENSINGTON
P.O.
HEWITT
CITY
New R.O.
Playground
Lands
WAKEFIELD Rd
TCE.
laide
wl. Club
ark
TELS
Rd





Bureau of Meteorology,
ADELAIDE 5000

2nd December 1976

AUSTRALIAN METEOROLOGICAL ASSOCIATION INC.

Dear Member,

At the suggestion of your Committee Members, I am including an information type letter with the 1976 issue of "Monana". Because of printing costs it has been necessary to restrict this publication to once a year but we hope that each issue will be larger and contain more articles than formerly.

The Committee is always looking for new ideas. We would appreciate suggestions of articles for inclusion in "Monana" and suggestions re types of talks or other activities to be covered in our regular programme of meetings. We have tried to cover a wide range of subjects in the talks which, in 1976, have included the following:

Survival in Antarctica
Weather and Wine
Presenting the Weather through the Media
Weather and Plant Diseases
Wind Energy
Solar Salt.

We have been fortunate in having the use of the Mineral Foundation building as a venue this year as scientific societies are not charged rental and therefore it has not been necessary to increase subscriptions. We plan to use this venue for the first meeting next year (3rd February) but, thereafter, we will be able to use the Conference Room in the Bureau's new building at 25 College Road, Kent Town (again without cost). I am sure members will be interested in a tour of inspection of this rather unusual building, so the first meeting there will include such an inspection.

Our current membership stands at 116. There have been five resignations in the 1975/76 year but we have welcomed the following as new members:

Mr A.G. Beales
Mr K.H. Beresford
Mr G.R. Bigg
Mr R.A. Bigg
Mr G. Bottrell
Mr J.W. Chigwidden
Miss P. Chigwidden
Mr S.N. Gummow
Mr A.M. Kernich
Mr B.L. Price
Mrs L.C. Ranford
Mr R.J. Richardson
Mr H.H. Salisbury
Mr G. Vecchio
Mr P.W. Webb
Mr M.S. Weeden
Mr I.R. Williams

On behalf of the Committee, I would like to extend to all members (new and old) the compliments of the coming Festive Season and best wishes for 1977.

Yours sincerely,

.....

A. Brunt
President,
Australian Meteorological Assoc.

MCALISTER PRINT 4687/76